DOCUMENT RESUME

ED 125 617 IR 003 704

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TITLE Computer Usage in the College-Credit High School Biology Curriculum.
PUB DATE 4 May 76
NOTE 12p.; Paper presented at the Association for Educational Data Systems Annual Conference (Phoenix, Arizona, May 4, 1976)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Advanced Placement Programs; *Biology Instruction; Botany; College Preparation; College Science; *Computer Assisted Instruction; Data Processing; *Laboratory Procedures; Physiology; Review (Reexamination); Secondary Education; Secondary School Students; *Simulation

ABSTRACT

Students of advanced life science courses at Beverly Hills High School, California, are able to approximate a wide variety of life process experiments through use of computer simulations. Students are taught to use the BASIC language and to execute programs on the Hewlett-Packard 2000 Access series. Computer programs are used to enhance instruction by providing: (1) unit reviews; (2) self-tests; (3) analyses of laboratory data; and (4) simulations of life processes. One program, SPHOTO, enables students to observe and quantitatively analyze the process of photosynthesis. A sample SPHOTO dialog is provided. (EMH)

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COMPUTER USAGE

IN THE COLLEGE-CREDIT

HIGH SCHOOL BIOLOGY CURRICULUM

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IR003704

One of the primary objectives of the upper division biology classes at Beverly Hills High School is to prepare students for the rigorous college curriculum in the life sciences. The three classes, Advanced Placement Biology, Advanced Physiology, and Advanced Botany have all been developed to meet the requirements of the college-bound science student. The purpose of the Advanced Placement Biology course is to prepare students for the Advanced Placement Examination offered by the College Entrance Examination Board of Princeton, New Jersey. If the student passes this examination, he is exempt from first-year biology at most major colleges. Upon completion of Advanced Botany and two essay-examinations, a student will receive a year's college credit in Botany from the University of California at Berkeley Extension. In light of this, our staff feels obligated to offer demanding biology classes that will offer the same material as a typical college course. The areas of investigation include biochemistry, energy transformations, cell anatomy and physiology, Mendelian genetics, chemical genetics, development taxonomy, evolutionary process, nutrient procurement and processing, gas exchange, internal transport, cellular respiration, hormones, nervous control (neuron and ANS) and ecological relationships among living organisms. Extensive college-level laboratory experiences using appropriate apparatus and techniques are integrated to provide an introduction to an exemplification of, and reenforcement of the topics presented in the discussion and lecture material. However, we feel that

there are experiments that cannot be performed accurately for want of time and equipment in the classroom. It is possible to simulate the action of any organism or group of organisms on a computer, and with the addition of the Hewlett-Packard 2000 ACCESS Series, we feel we now have this capability. All the programs on the System are in the BASIC language. Although this is a rather simple language, it can be easily taught to the students without requiring any special prerequisites or additional course work and within a few weeks nearly all students are able to develop their own programs in which to enhance their own learning and enjoyment.

Computer programming at Beverly Hills consists of four main types. First is Unit Review. The instructor's lecture is typed on to the System with key words omitted from the program. When the student runs the program, he must supply the correct answer in order to complete the program. If a wrong answer is inputted, the correct answer is supplied by the program after two attempts. We feel that this type of programming offers two significant advantages. If a student is absent from a lecture, he can easily receive a copy of the instructor's lecture and, secondly, the program serves as an excellent review for the student who has thoroughly studied the material. A second type of programming is the Self-Test. After the completion of each unit and before the examination, a series of typical multiple-choice or fill-in test questions are programmed on to the System. The student is then allowed to take this "pre-test" to determine what areas

require further study. Whenever possible, a page number from the required text is supplied for quick reference for a mistaken entry.

The third type of programming is analysis of laboratory data. Many times it is both impractical, as well as time-consuming, for the student to do the simple mathematical calculations required to determine if his experiment is proceeding correctly. Often experiments have had to be postponed or cancelled to allow the student time for these calculations. Thus, a simple computer program is developed to perform these calculations and allow the student to continue with his experiment. A program which will verify results from a genetics experiment through the use of Chi Square is an example of such programming. A student must know the basic structure of Chi Square in order to input the data, but now is not bound by the mathematical calculations.

The fourth type of programming and the one most fascinating, I believe, to the student and the instructor is the Simulation of Life Processes. Many experiments, due to locality, lack of sophistication of laboratory equipment, complexity in measuring the biological process, and time required for the experiment could not be completed in the lab. The reenactment of Darwin's finches or the Lock and Key Enzyme model in biochemistry are typical examples of these biological simulations.

The second portion of this paper deals with one such simulation developed to allow the student to observe and investigate quantitatively the biochemical processes that occur in

nature. With SPHOTO the student is able to simulate the process of photosynthesis in a leaf by inputting varying amounts of carbon dioxide, water, temperature, color of light and light energy and determine their effect on photosynthesis in terms of the production of glucose, oxygen, and water. The values are in milliliters for carbon dioxide, oxygen, and water; Celsius for temperature, photons for light energy, and grams for glucose. (please see enclosed computer print-out.)

The first stage of the program prints a brief introduction to the actual biochemical processes in photosynthesis, as well as instructions on how to input the experimental data. If the student does not wish to vary any of the above-mentioned physical or chemical factors, the program will print out the results of a standard run which the student can designate as a control for further investigations. The program then asks the student if he wishes to change any of the factors. The operator can change one or as many factors as he wishes to investigate.

If values are changed, the program then types out the new results based on the inputted data. At this point the program prints out the number of actual photosynthetic cycles and then determines which of the factors eventually limits the rate of photosynthesis.

This simulation is applicable at all levels of high school botany, including Advanced Placement Biology, or first-year college botany. A worksheet with suggested activities and problems has

also been developed to accompany the program.

In conclusion, it is felt that the computer, through unit review, self-tests, analysis of laboratory data, and simulation of biological activities has added a new dimension to our upper division classes and has made biology both academically challenging and stimulating to the contemporary student.

TYPICAL PROGRAM PRINT-OUT
(Student Responses Are Underlined)

SPHOTO

DO YOU WANT INSTRUCTIONS? (TYPE YES OR NO)
?YES
THIS PROGRAM DEALS WITH THE PROCESS OF PHOTOSYNTHESIS.
IN PHOTOSYNTHESIS CARBON DIOXIDE (CO2) AND
WATER (H2O) IN THE PRESENCE OF LIGHT PRODUCES
SUGAR (C6H12O6), OXYGEN (O2) AND WATER (H2O).
THE OVERALL EQUATION FOR PHOTOSYNTHESIS:

6CO2 + 12H2O ----→ C6H12O6 + 6O2 + 6H2O

IN THIS EXPERIMENT YOU WILL BE ABLE TO
VARY THE COLOR OF THE LIGHT USED, INTENSITY
OF THE LIGHT, TEMPERATURE, AMOUNT OF CARBON DIOXIDE
AND THE AMOUNT OF WATER.

THE PROGRAM WILL TELL YOU HOW MUCH
SUGAR, OXYGEN, AND WATER IS BEING PRODUCED
AND WHAT FACTOR EVENTUALLY STOPPED THE REACTION
(THE LIMITING FACTOR).

A TYPICAL EXAMPLE WOULD BE:
FOR EVERY 134400 ML OF CO2, 216 ML OF H20?
AND 48.16*10↑23 PHOTONS OF RED LIGHT AT 20 DEGREES CELSIUS
THE FOLLOWING IS PRODUCED:
GLUCOSE: 180 GR
OXYGEN: 134400 ML
WATER: 108 ML

NOW YOU MAY TRY THE ABOVE EXPERIMENT
BY VARYING ANY FACTOR THAT YOU WANT
IF YOU DO NOT VARY A FACTOR THE
FOLLOWING VALUES WILL BE USED:
134400 ML of CO2, 216 ML of H2O, and 48.16*10↑23 PHOTONS
OF RED LIGHT AT 20 DEGREES CELSIUS.
YOU MAY VARY A FACTOR BY TYPING IN THE NUMBER
ASSOCIATED WITH THE FACTOR
#1 CARBON DIOXIDE
#2 WATER
#3 COLOR OF LIGHT
#4 LIGHT INTENSITY (PHOTONS)
#5 TEMPERATURE (CELSIUS)

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WHICH FACTOR DO YOU WISH TO VARY?
IF YOU DO NOT WISH TO CHANGE ANYTHING TYPE A 6
?6

AMOUNT OF GLUCOSE PRODUCED: 18Ø GR
AMOUNT OF OXYGEN PRODUCED: 1344ØØ ML
AMOUNT OF WATER PRODUCED: 1Ø8 ML

THE PLANT RAN OUT OF WATER

THE PLANT RAN THROUGH THE PROCESS OF
PHOTOSNYTHESIS 3.Ø1ØØØE+23 TIMES.

DO YOU WISH TO RUN THE EXPERIMENT AGAIN?  (TYPE YES OR NO)
?YES
WHICH FACTOR DO YOU WISH TO VARY?
IF YOU DO NOT WISH TO CHANGE ANYTHING TYPE A 6
?3
WHICH COLOR OF LIGHT DO YOU WANT TO USE
 #1 BLUE
 #2 GREEN
 #3 YELLOW
 #4 RED
?2
WHICH OTHER FACTOR DO YOU WISH TO CHANGE?
TYPE 6 IF YOU ARE THROUGH
?6

AMOUNT OF GLUCOSE PRODUCED: 6Ø GR
AMOUNT OF OXYGEN PRODUCED: 448ØØ ML
AMOUNT OF WATER PRODUCED: 36 ML

PHOTOSYNTHESIS HAS STOPPED BECAUSE THERE IS
NOT ENOUGH LIGHT (PHOTONS).

THE PLANT RAN THROUGH THE PROCESS OF
PHOTOSYNTHESIS 2.ØØ667E+23 TIMES.

DO YOU WISH TO RUN THE EXPERIMENT AGAIN? (TYPE YES OR NO)
?NO

DONE
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SPHOTO LAB WORKSHEET

It is possible to simulate the action of any organism on a computer. In this lab you will simulate the process of photosynthesis in a leaf. You will be able to vary the amount of carbon dioxide, water, color of light, and light energy and determine the effect on photosynthesis. As you complete the lab on the computer, please answer the following questions:

1. a) Holding all other values constant, if equal amounts of water and carbon dioxide are supplied to a plant, which will limit the rate of photosynthesis?
   b) In what ratio should the carbon dioxide to water values exist for a plant?
2. a) What color light is best for photosynthesis?
   b) Why do you think this is so?
   c) Rank the other three colors in order of efficiency.
3. Would supplying twice the amount of light double the rate of photosynthesis? Why or why not?
4. Calculate the amount of sugar, oxygen, and water produced during <u>one</u> complete cycle of photosynthesis.
   (Hint: $\frac{\text{amount of glucose produced}}{\text{number of photosynthesis cycles}}$)
5. Construct a graph illustrating the effect of temperature on photosynthesis.

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